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BULLETIN 299 MAY, 1921

REPORT OF PROGRESS ON ANIMAL HUSBANDRY INVESTIGATIONS IN 1920

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BULLETIN 299

REPORT OF PROGRESS ON ANIMAL HUSBANDRY INVESTIGATIONS IN 1920.[1]

By John W. Gowen

This brief abstract in conformity with previous reports deals with the progress which has been made during the past year in the animal husbandry investigations carried on by the Maine Agricultural Experiment Station. Among the problems analyzed were, studies on the conformation of the dairy cow to determine whether there was a difference in the ability of men, trained in dairy work, to determine from a cow's conformation what her milk yield over a 365 day lactation would be; the relative value of the short time test of dairy cattle as measure of the cow's ability as a milk producer or butter-fat tester; the study of the butter-fat requirement for entry into the advanced registry of the different breeds to determine its fairness to all ages of cows within these breeds; the effect of age on increasing twins or multiple births in dairy cattle; the performance of certain Holstein-Friesian sires as measured by the milk yield of their daughters; a study of inbreeding to determine its merits or defects in producing high yielding or low yielding dairy cattle; study of the value of a famous sire within a pedigree as an indication of the probable worth of the animal so pedigreed; study of milk content to determine the relative content of its solids when it is modified to a definite butter-fat content and when it is a natural milk of the same butter-fat content; study of the inheritance of milk yield and butter-fat percentage as shown by the records of our crossbred herd. These features of the work will be discussed individually.

Ability of Different Men to Judge the Dairy Cow for Milk Yield

In the report of 1919 on the animal husbandry investigations there was given the results of a study of the physical con-

[1]Papers from the Biological Laboratory, Maine Agricultural Experiment Station, No. 139.

formation of the Jersey cow in relation to milk yield. The points of conformation which bear more particularly on milk yield are the total score of the cow or what might be called the cow taken as a whole; the character, size and elasticity of the milk veins; the size and quality of the whole udder; the size of

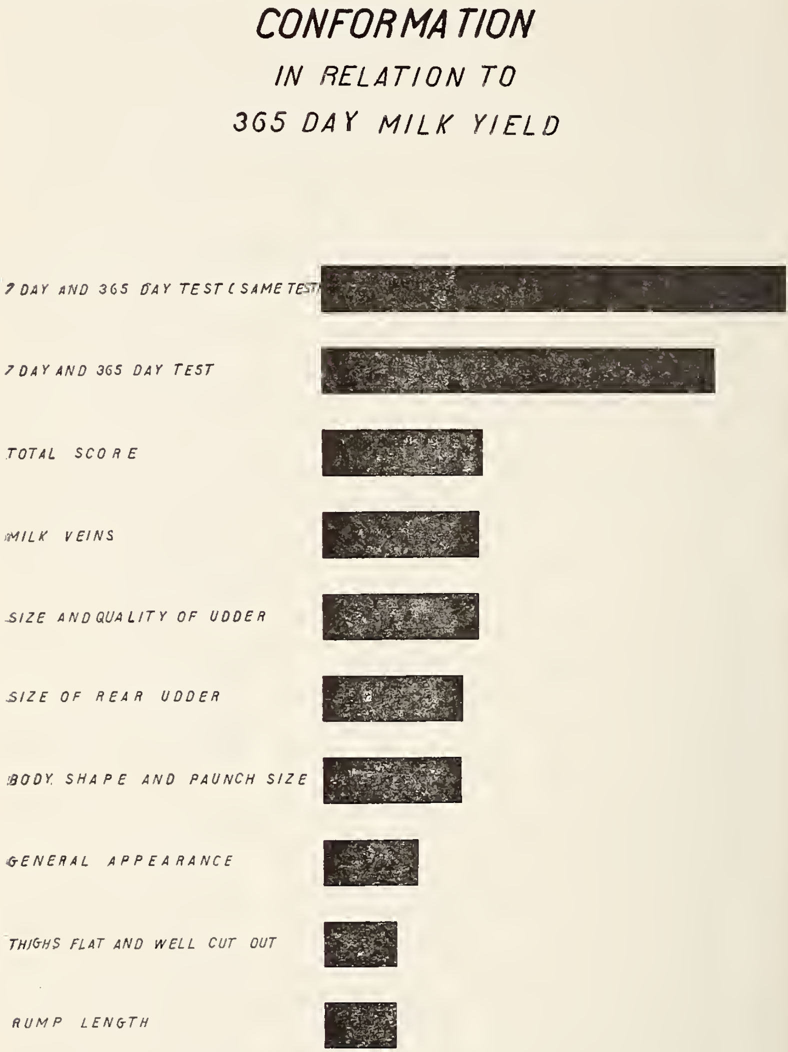

FIG. 37. The length of the back bars indicates the relative value of the different points as measures of milk producing capacity.

the rear udder; the shape and size of the paunch; the general appearance of the cow; the thighs flat and well cut out and the length of the rump. It was further pointed out that a milk record of Holstein-Friesian cows even though it was only taken for 7 days, was about 2½ times as good an indicator of the cow's ability as were any of the physical points. The relative merits of these points are indicated as heavy black bars in figure 37. The length of these bars indicates the relative merit of the points on conformation as measures of the cow's milk producing capacity.

It will be observed that the 7 day milk yield (of the points considered) is the best measure of the milk yield for a 365 day lactation milk yield when it is itself a part of the same lactation. The next best measure of the 365 day milk yield is the 7 day test when the 7 day test comes in another lactation from that of the 365 day test. The 7 day test is clearly of nearly equal value in determining milk yield of the lactation of which it is itself a part and of a subsequent lactation of which it is not itself a part.

Of the points on conformation, the total score has the greatest value in determining milk yield over the 365 day period. Its value is, however, only about ½.5 of that of a milk yield of 7 days. Closely following this as an indicator of 365 day milk yield are milk veins, etc., as indicated above.

Pausing to consider briefly these facts we see that a 7 day test might be considered as an objective test whereas the value of the points on conformation are a subjective test for the cow's producing ability. That is, the 7 day test is simply dependent on the reading of the scales that weigh the milk whereas the use of scale of points to judge a cow for milk yield depend, not on any external scale, but on the mental processes or mental ability of the judge to so balance his cuts to show the true worth o the cow. From this it follows that the conformation of the cov as a measure of milk yield would in all probability be subje to the personal bias of the judge.

This is in fact shown to be the case on study of the rec ords. There are 19 men, all well trained dairymen, who have judged enough cattle with milk yield to make a test of their ability as judges of these cows for milk yield. Nine of these men clearly could judge dairy cattle by the score card and select the better milkers. On a scale ranging from 1 to 0 and 0 to —1 (correlation scale) these men varied from the most accurate judge of milk yield from the conformation of .614 to the least accurate judge of —.098. The average ability of these men is .246 or they are on the average about 25% better judges of dairy cattle for milk production than the average trained dairymen shown in figure 1. Clearly some men are good cattle judges. Equally clearly some men cannot judge cattle for milk production by the use of the score card. Such being the case the individual man will do well before he selects cattle by their conformation alone to make a sufficient test to convince himself that he is one of those gifted men who can judge dairy cattle.

On the other hand almost anyone can weigh milk. No personal equation need be present in recording the weights. Such being the case when they are obtainable the dairymen or buyer would do well to consider the milk yield carefully in selecting dairy cows as indicated by the figures above.

RELATIVE VALUE OF THE 7 DAY AND 365 DAY MILK YIELD AS A MEASURE OF THE MILKING CAPACITIES OF THE COW.

All of the readers of this bulletin know that in the Holstein-Friesian breed there are several kinds of tests entered into the advanced registry. Among these tests are the 7 day, 30 day, semi-official or long time test. Up to recently these tests have required the cow making them to pass the 7 day registry requirement before the longer time test could be entered in the blue book. In its earlier history the Jersey breed also had the 7 day test. This has been largely dropped to be replaced by the semi-official record.

During the past few years a controversy has been in progress as to the relative merits of these tests, particularly the 7 day and the 365 day in determining the relative merits of the different animals within the breeds.

In the author's opinion one of the prime objects in the blue book record of cattle is to enable not only the owner but also every breeder to examine the record and determine from it what that cow may produce in lactations at a date later than that of her blue book record. If such is in truth the case, then the inquiry apparently leads to the following questions.

1. Does the 365 day test predict the relative[2] milk yield and butter-fat percentage of a subsequent 365 day lactation with sufficient accuracy to make the 365 day test of value?

2. Does the 7 day test predict the relative milk yield and butter-fat percentage of the 365 day lactation record of which it is a part with sufficient accuracy to make the 7 day test of value?

3. Does the 7 day test predict the relative milk yield and butter-fat percentage of the 365 day lactation of which it is not a part with sufficient accuracy to make the 7 day test of value?

The second and third do not, of course, require that the 7 day test have a milk yield or a butter-fat test equal to the 365 day test, they only require that the position occupied by the cow among the blue book sister cows in her 7 day test shall be closely similar to the position occupied by this same cow in her year test. On this ground the fact that the 7 day test butter-fat percentage is higher than the year test butter-fat percentage has little weight for like the 7 day milk yield some knowledge must be had of what the conversion factors should be, before either test can predict even approximately the subsequent year record. Similar reasoning likewise hold for the 365 day record of one lactation in comparison with that of another lactation.

A physiological factor comes into this discussion in regard to the 7 day tests for butter-fat percentage. The assertion is commonly made that feeding a cow heavily so that her body lays on a heavy amount of loose fat before her lactation commences will cause her to rapidly milk off this fat into her milk and thus increase her butter-fat percentage above that of other cows. Such a condition of affairs is commonly used as an argument against the use of 7 day tests. On *a priori* grounds there may be little to this argument; it is subject to test, however. Most dairymen make it a practice to have their cattle in good condition whether they are planning to make a 7 day or year test. Such being the case it does not appear likely that there

[2]The word *relative* is inserted here because, as is well known, the milk yield of cows change with age. The cow will not be expected to have the same number of pounds of milk in one lactation as in another but will rather be expected to maintain a milk yield such that she retain her relative position among her sister cows in the subsequent lactation that she had in the lactation semi-official test.

would be any cows in extremely poor condition in regard to their body fat, in fact it appears more probable that the cows approaching test are on the whole in pretty good shape. Under such circumstances this fattening should show an approximately equal effect on all cattle, thus making only a constant factor in the prediction of the year test from the 7 day test. Furthermore, it is generally admitted that the year test is also a gainer in this conditioning of the cow for advanced registry test. The results given below from a study of the advanced registry data assist to some degree in the analysis of this problem.

In connection with other investigations, data were gathered on the 7 day and year test of Holstein-Friesian cows. These data are believed to include all the 365 day test cows of the Holstein-Friesian advanced registry, with subsequent semi-official retest records of 365 day duration. Over 300 records are included. The seven day tests and 365 day tests during the same lactation include most of the records contained in the blue books from volumes 27 down. These records were selected at random and include more than thirteen hundred cows. The year test cows having a 7 day test in another lactation likewise were selected at random from volumes 27 down and include over 300 cows.

The calculation of the data to determine the relative value of the 7 day and 365 day test as an indicator of the cow's possibilities as a milker have been done for the separate age groups.[3] The average of the correlations is then taken for each class. The results of this study are shown in figure 38.

The length of the black bars[4] represents the relative value to be attached to the various tests. As may be noted the bars are all of good length. The first, fourth and seventh bar represent the relative values of the different tests on milk production. The semi-official 365 day test measures the production of a sub-

[3]This is necessary because of the fact that the increase of milk yield with age (for the 7 day and 365 day of the same lactation) will in and of itself increase the correlation coefficient should these data be lumped, especially should such lumping include the early ages. By similar reasoning the correlations coefficients for the 7 day test with 365 day test and the 365 day test with 365 day test at different lactations will be lowered if all data irrespective of ages are lumped together.

[4]The lengths of the black bars represent the actual values of the average correlation coefficients.

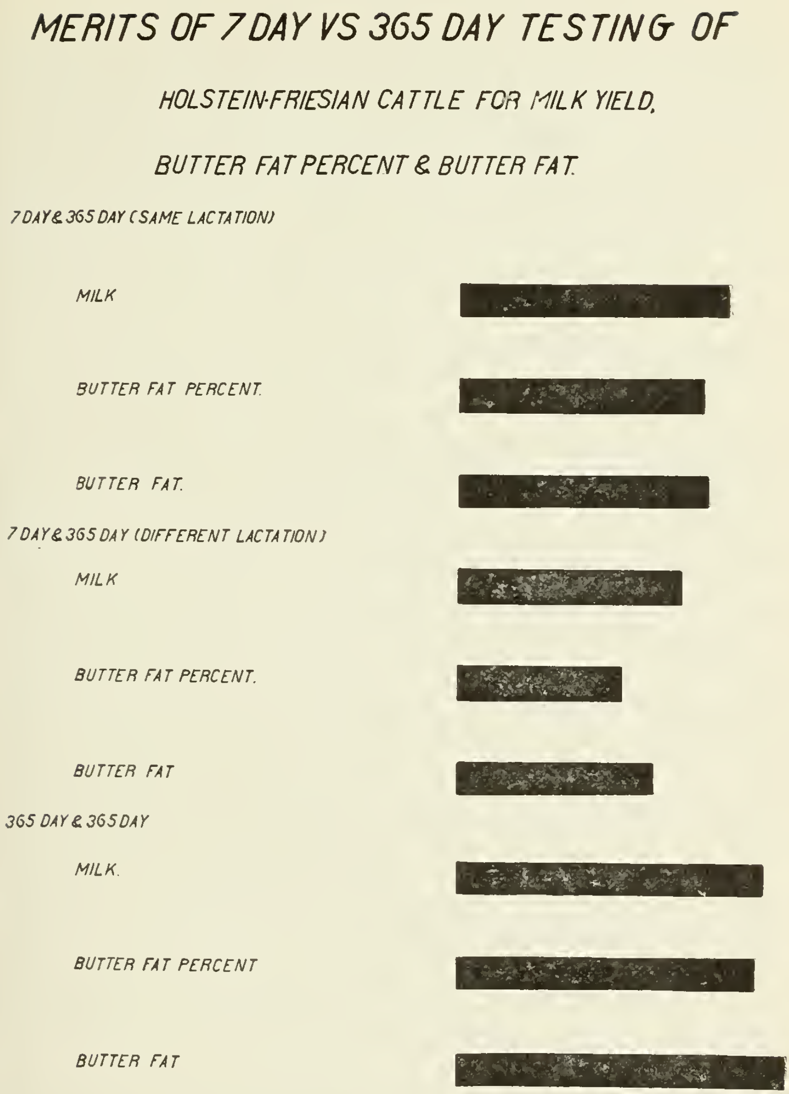

FIG. 38. Relative value of the 7 day and 365 day test as indicating a cow's capacity as a milk producer. The length of the heavy bars represents the relative weight to be attached to the various tests.

sequent semi-official test (seventh bar) slightly better (.08 of correlation more) than does the 7 day test measure the 365 day lactation record of which it is a part (first bar). The 7 day test measures the 365 day test in the same lactation (first bar) slightly better than does the 7 day test predict the milk yield in a subsequent 365 day lactation (fourth bar). Considering the values of the probable errors of these correlation coefficients their differences are probably slightly significant. Such being the case the conclusion may be drawn that the 365 day lactation is a slightly better measure of a cow's milk producing capacity for a subsequent lactation than is the 7 day test a measure of the cow's milk producing ability in its own 365 day lactation or a subsequent 365 day lactation of which it has no part.

All correlations are significant and high if the results are compared with correlations on similar variables.[5]

Comparison of the relative value of the 365 day and 7 day test for butter-fat percentage in figure 38 shows that the black bar for the 365 day butter-fat percentage (eighth bar) correlated with a subsequent lactation's 365 day butter-fat percentage is longer than the bars representing the relative values of the 7 day test correlated with the 365 day test. The order of merit of the test is 365 day with 365 day test; 7 day with 365 day test of which the 7 day test is a part of the 365 day test and the 7 day with the 365 day test of which the 7 day test is no part. The lengths of all the bars are somewhat shorter than are the lengths of the bars for milk yield. The comparison of the lengths of the bars for 7 day and 365 day test for the same lactation and for different lactations show that the butter fat percentages of the same lactation are more accurately predicted by the 7 day test than are the butter-fat percentages of a different 365 day lactation predicted by the 7 day test. Such a relation points to possible ground for the contention that the butter-fat percentage may be relatively more affected by causes like the fitting of the cow for test of short duration than for test of long duration.

The butter-fat production is, of course, only a multiple between the milk yield and butter-fat percentage. Figure 38 shows

[5]Gowen, John W. 1920. Studies in Milk Secretion V. On the Variations and Correlation of Milk Secretion with Age. In Genetics, Vol. 5, pp. 111-188.

Gavin, William. 1913. Studies in Milk Records on the Accuracy of Estimating a cow's Milking Capacity by her first Lactation Yield. In Jour. Agric. Sci. Vol. 5, pp. 377-391.

that the same general facts are shown by it as are shown by the milk yields and butter-fat percentage tests.

The size of these correlation coefficients clearly points to the fact that the short time test and the long time test both are good measures of the cow's abilities as a milk producer, good enough for both to be retained to play their part in assisting to increase the milk yield and butter-fat percentages of the breed by increasing the records on a greater number of cows within these breeds.

It is of some interest to examine another study of a quantitive nature which attempts to throw light on this problem.[6] Within this bulletin it is shown that the correlation coefficient for the semi-official and 7 day milk and butter-fat yields all lumped together is approximately +0.7. From this the conclusion is drawn that, "the correlation .702 is for certain purposes a high degree of correlation, but it is not a high degree of correlation between two measurements of the same thing." Continuing he says "it further follows that since the correlation between 7 day and semi-official test is not high, it is not safe to attempt to use the 7 day as a criterion by which to judge semi-official production." The point of this quotation all hinges on what correlation may be considered high for milk yield, etc., in dairy cattle and on the definition of "measurements of the same thing." By "measurements of the same thing," Mr. Yapp appears to mean the 365 day test. It seems to the author, however, that what both measurements are aiming at is the total milk yield, etc., of the cow through her life time. If the author's view is held, inquiry must be made into how accurately the 365 day test measures the cow's capacities as a producer of milk, in fact on either view such a comparison seems desirable.

If all data are lumped the correlations for the 365 day test and subsequent 365 day retest are 0.6 for milk and 0.5 for butter-fat. The comparison is consequently more favorable to the 7 day test than to the 365 day test. Comparison should probably be made on separate age distributions, however, for as previously pointed out the 7 day test correlation was increased by lumping all records and the 365 day decreased, it therefore

[6]Yapp, W. W. 1919. A study of the relative reliability of official tests of dairy cattle. In Bul. 215. Illinois Agr. Expt. Sta. pp. 323-329.

follows that the conclusion based on figure 38 are more likely to be correct than are conclusions based on method used by Mr. Yapp of lumping records irrespective of age. Such being the case the following conclusions may be drawn with regard to the tests.

1. The 7 day and 365 day test have a correlation coefficient high enough to be of material value in determining the worth of the cow.

2. The 365 day test predicts more accurately the milk yield or butter-fat percentage of the same cows in a subsequent lactation than does the 7 day test.

3. The 365 day test should, therefore, be given more consideration than the 7 day test when both are available.

4. If the 7 day test holds other material advantages (as for example less expense or increasing the number of cows tested) the correlation coefficients are sufficiently high so that it would be desirable to retain the test.

MEAN BUTTER-FAT YIELD OF THE DIFFERENT BREEDS AND THEIR ADVANCED REGISTRY REQUIREMENTS.

All are familiar with the fact that each breed of dairy cattle has a registry requirement of a certain number of pounds of butter-fat for admission of these cows into the advanced registry. It is of interest to inquire if this requirement is an equal handcap to all of the advanced registry cows which make the entry into the advanced registry.

Figure 39 shows the mean butter-fat yield of the Holstein-Friesian advanced registry cows for the 365 day period as the curved line. The advanced registry requirement for entry is given as the broken line. This starts at 250.5 pounds as the requirement for the butter-fat of the cow two years or under and rises from that point to 360 pounds for the 5 year old cow. For cows older than 5 years the requirement remain 360 pounds. A line is drawn parallel to this requirement for entry line. This line is so chosen that it crosses the mean butter-fat yield of the advanced registry cows at the 2 year ages. The line is shown as a dotted line. Comparison of the dotted line with the curved line shows clearly the difference between the actual yield of these advanced registry cows and the requirement.

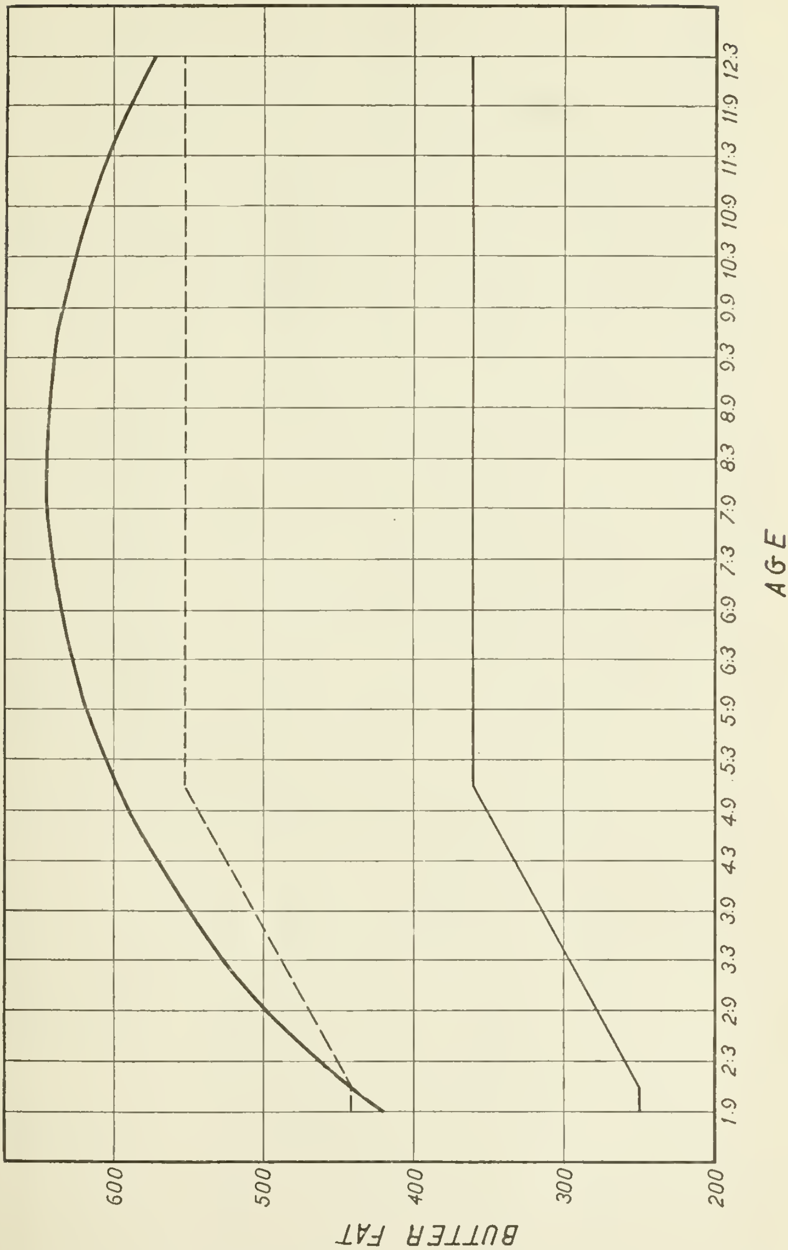

FIG. 39. Comparison of the requirement for entry into the Holstein-Friesian Advanced Registry and the actual mean butter-fat yield of these advanced registry cows.

The ages below two years are clearly handicapped the most in competing for prizes, etc. From two years to five years there is a steadily increasing handicap given to the cow until mature age is reached. This mature age is clearly not a 5 years as customarily assumed but is slightly over 8 years. From the 8 year age the milk yield declines as the age advances.

This handicap amounts to a good deal. For instance relatively speaking, the cow at 6½ to 9½ years needs approximately 80 pounds less butter-fat than she would need as a two year old to make a record for entry. Such handicaps offer the breeder a chance to choose the most favorable time to try to get the relatively low yielding cow into the advanced registry.

Unfortunately this curve for the mean butter-fat yield of these advanced registry Holstein-Friesian cows cannot be considered as entirely representative of the whole breed for it can be shown that the cows composing it are a selected sample of even the advanced registry cows. It will be remembered that until recently there has been a requirement that cows must make the 7 day test before they can make the 365 day test. Now it can be shown that this 7 day test is higher in milk yield and butter-fat percentage for those cows which are tested for the 365 day period than is the test for all the cows who make the 7 day test. Such being the case, with the relatively high correlation which exists between the 7 day and 365 day test, it follows that this selected group would on their 7 day test have a butter-fat test slightly higher than the average of all the advanced registry tested cows.

Figure 40 shows the mean butter-fat yield of the advanced registry Guernsey cows. The curved line represents the mean butter-fat yield for the different ages of test. The broken line represents the butter-fat requirement for entry. The dotted line is drawn to be parallel with the requirement for entry line and to cross the mean butter-fat yield at 2 years old.

The dotted line shows that the cows who were 2 years old when tested for entry were most handicapped in their making the advanced registry. From two years to about 3 years and 5 months the handicap becomes progressively less. The point 3 years and 6 months was one of the ages at which the cow could most easily make the requirement for entry. From 3 years and 6 months to 5 years the margin between the requirement and

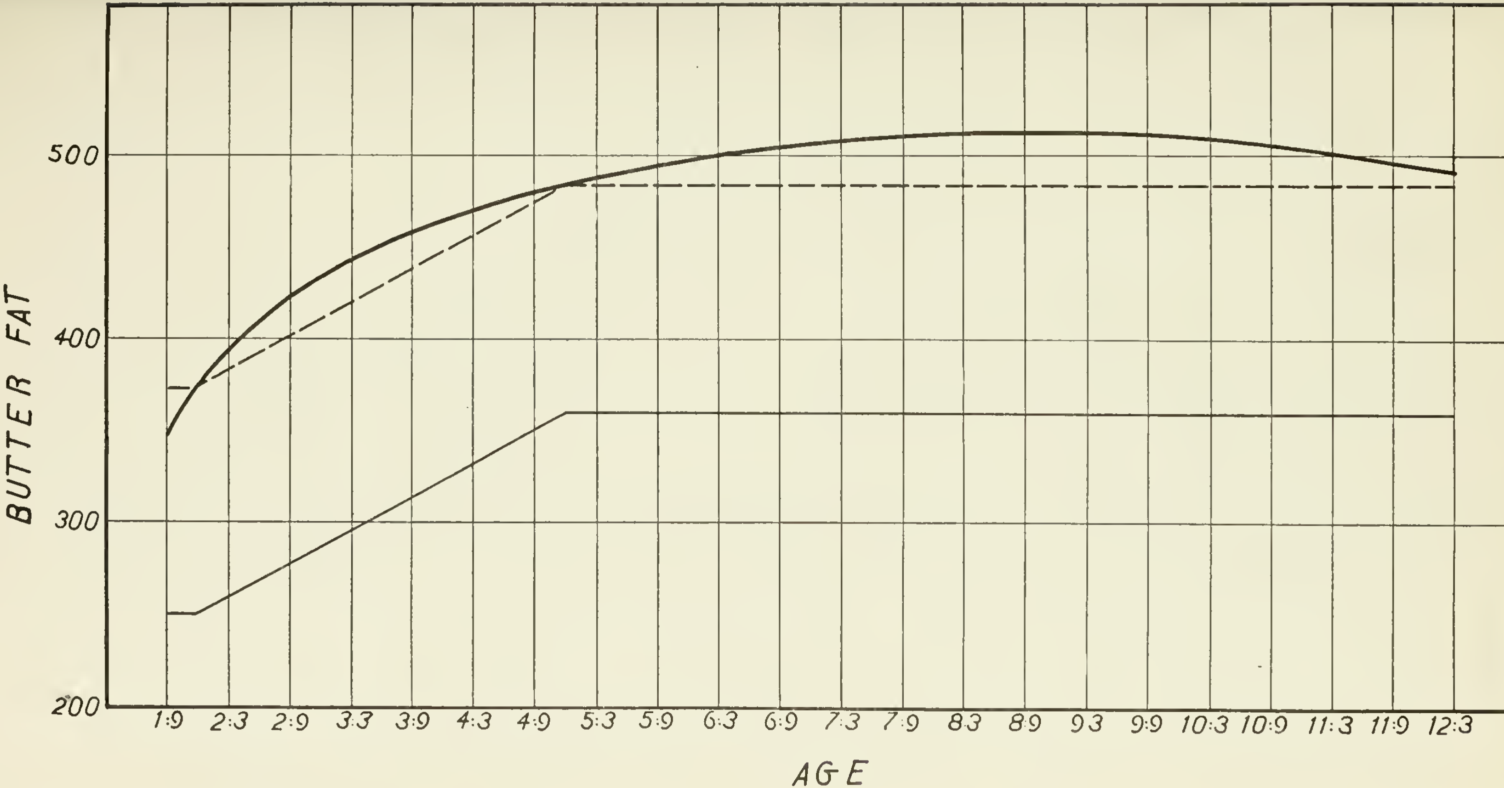

Fig. 40. Comparison of the butter-fat requirement for entry into the Guernsey Advanced Registry and the actual mean butter-fat yield of these advanced registry cows.

entry becomes progressively less until at 5 years the cow has little or no advantage over the cow at 2 years old. From 5 years to 7 years the margin between requirement and average butter-fat yield of the advanced registry Guernsey cows becomes progressively larger increasingly favoring the cow tested at these ages. From 9 years to old age there is a slight decline in the average butter-fat production thus causing a decrease in the relative handicap given. The handicaps received by the older aged cows, about the age of 8 years, amounts to nearly 30 pounds of butter-fat. The handicap received by the cows at 3 years and 3 months amounts to something over 20 pounds as compared with the production required at the 2 year age and at the 5 year age.

Figure 41 shows the mean butter-fat yield of the registry of merit Jersey cows in volumes 1 to 5. The curved line represents the yield for the different ages at which the 365 day test was commenced. The broken line represents the requirement for entry into the registry of merit, at the several ages when the test was commenced. The dotted line is drawn parallel to the requirement for entry line so as to cross the mean butter-fat yield at the age of 2 years.

The dotted line parallel to the requirement for entry line shows that the ages less than 2 years old and at the ages older than 11 years and 8 months the cows are more handicapped on the average than are the cows tested at two years. This handicap amounts to between 10 and 20 pounds of butter-fat for the cows at the ages 1 year and 9 months and at the ages 12 years and 3 months. From the 2 year age to the 11 years and 8 months age the registry of merit cows who have made the entry into the registry of merit had a slightly better chance to make this entry than did the cows tested younger or older than these ages. For the cows in the younger age groups the age of 3 years to 4 years and 3 months appears quite favorable. The cows in the so-called mature class have a good opportunity to make the requirement at the ages 6 to 9 years. It is clear that the cows competing for any prizes in the mature age groups have a better average chance to reach those prizes at the ages 7 to 9 years than do the cows at the 5 year old age.

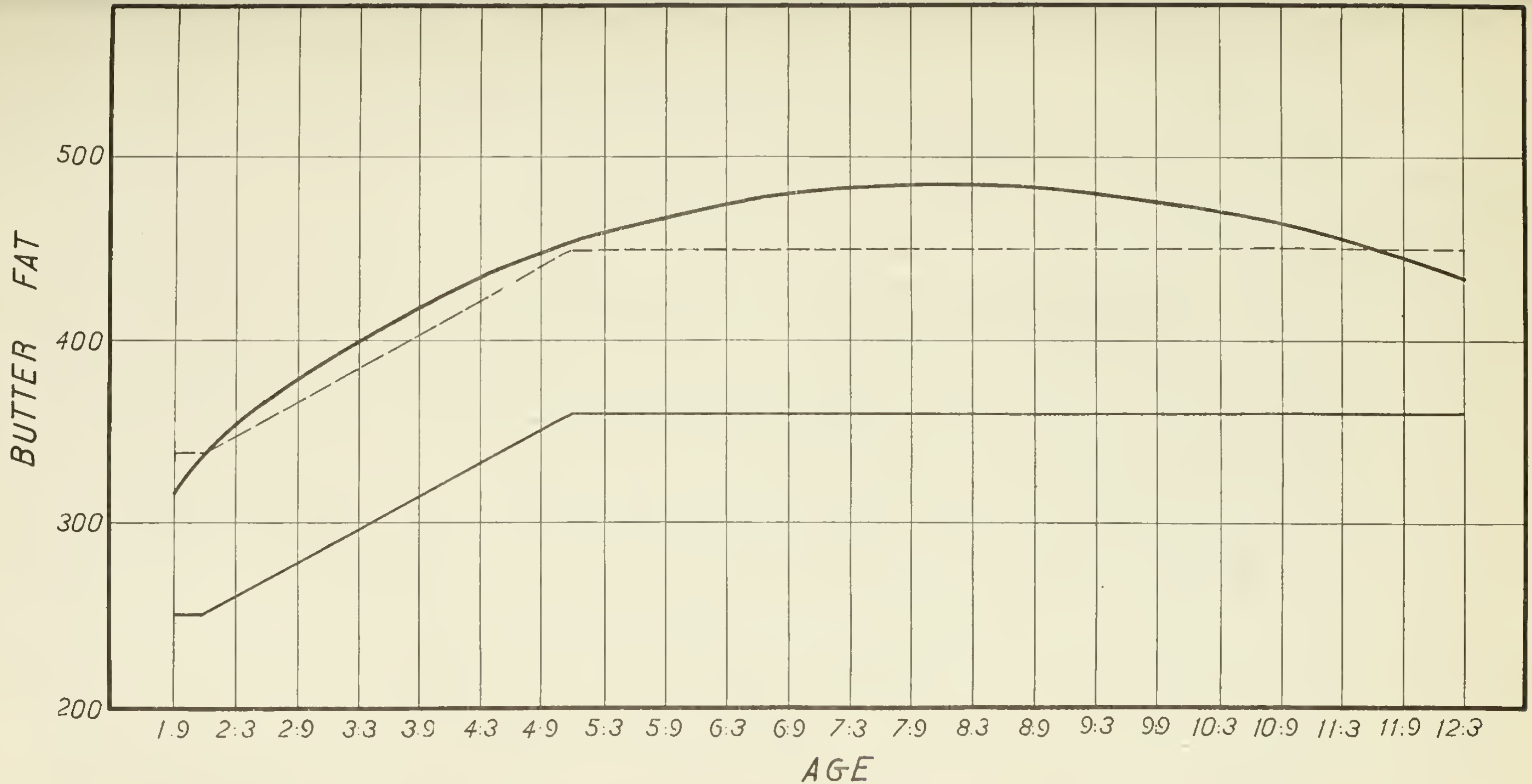

FIG. 41. Comparison of the butter-fat requirement for entry into the Jersey Registry of Merit and the actual mean butter-yield of these registry of merit cows.

RELATION OF TWINNING TO AGE IN DAIRY AND BEEF CATTLE.

It has been shown for man and for sheep that increase in age of the mother tends to increase the relative frequency of multiple birth over single birth. Such a physiological increase of the body activity is of particular interest to the geneticist who desires to study the inheritance of such a character. From this view point the data shown in tables 1 to 4 were collected. Table 1 shows the relative frequency of the sires ages for the five breeds Guernsey, Aberdeen-Angus, Holstein-Friesian, Jersey and Shorthorn which produced twin births.

TABLE 1.

Frequency of Sires' Ages When Twin Births Result.

Age	Guernsey Twins	Aberdeen-Angus Twins	Holstein-Friesian Twins	Jersey Twins	Shorthorn Twins	Total half years
1:0–1:6				2		2
1:6	6	5	50	38	32	131
2:0	14	11	92	38	67	222
2:6	15	11	67	63	72	228
3:0	15	15	67	59	73	229
3:6	18	4	85	47	60	214
4:0	14	7	53	41	49	164
4:6	7	4	47	42	48	148
5:0	8	4	35	31	39	117
5:6	9	2	39	24	25	99
6:0	2	3	18	13	22	58
6:6	1	1	12	18	16	48
7:0	5	2	15	12	16	50
7:6	5	3	13	7	5	33
8:0			4	8	11	23
8:6	2		8	5	5	20
9:0	2	1	2	2		7
9:6				3	2	5
10:0	1	1	3	4	1	10
10:6			3	6		9
11:0			1	2	3	6
11:6			1	2	1	4
12:0			3			3
12:6						
13:0						
13:6						
14:0			1			1
14:6						
15:0			1			1
15:6			2			2
16:0						
16:6						
17:0						
17:6						
18:0						
Total	124	74	622	467	547	1834

Table 2 shows the relative frequency of the dams' ages for the five breeds which produced twin births. The numbers are not exactly the same as those of table 1, because information in the Herd Book is not always available on the date of birth of an animal. The dams are the mothers of the twins whose sires' ages are given in Table 1.

TABLE 2.

Frequency of Dams' Ages Where Twin Births Result.

Age	Guernsey Twins	Aberdeen-Angus Twins	Holstein-Friesian Twins	Jersey Twins	Shorthorn Twins	Total half years
1:0–1:6			1	1		2
1:6	1		3	7	2	13
2:0	5	4	18	18	14	59
2:6	2	5	23	22	13	65
3:0	7	3	49	47	25	131
3:6	7	2	47	38	32	126
4:0	7	8	43	27	30	115
4:6	11	6	46	41	43	147
5:0	10	7	46	34	45	142
5:6	10	4	47	39	32	132
6:0	7	3	46	19	41	116
6:6	5	6	33	29	31	104
7:0	3	2	43	20	26	94
7:6	7	3	28	16	32	86
8:0	9	4	26	14	27	80
8:6	4	2	18	22	20	66
9:0	3	3	15	9	18	48
9:6	4		16	11	32	63
10:0	3	1	11	9	22	46
10:6		3	9	12	15	39
11:0	3	1	11	9	11	35
11:6	1		16	5	10	32
12:0	3		8	8	5	24
12:6	2	1	5	7	1	16
13:0	1		7	2	6	16
13:6	1	1	3	2	5	12
14:0	2		2	2	3	9
14:6						
15:0					2	2
15:6				1	1	2
16:0	1		1	2		4
16:6	1		2			3
17:0						
17:6				1		1
18:0						
18:6					1	1
Total	120	69	623	474	545	1831

A random sample of the ages of the parents for single births is of course necessary for comparison with the ages of the parents of multiple births. The frequency distributions for the sires' ages of the single births are given in Table 3.

TABLE 3.

Frequency Distribution of Sires' Ages Where Single Births Result.

Age	Guernsey Random Samples	Aberdeen-Angus Random Samples	Holstein-Friesian Random Samples	Jersey Random Samples	Shorthorn Random Samples	Total
1–2	1	4	44	14	7	70
2	93	57	365	236	111	862
3	98	84	408	294	149	1033
4	73	57	316	243	127	816
5	42	48	141	158	78	467
6	28	35	83	100	46	292
7	22	25	39	56	36	178
8	10	15	27	59	10	112
9	11	10	17	21	17	76
10	3	11	11	10	3	38
11	4	5	6	6	3	24
12		6	2	4		12
13		1		4		5
14		4		2		6
15		1	1	1		3
16						
17		2				2
18						
19						
20–21		1				1
Total	385	366	1460	1199	587	3997

TABLE 4.

Frequency Distribution of Dams' Ages Where Single Births Result.

Age	Guernsey Random Samples	Aberdeen-Angus Random Samples	Holstein-Friesian Random Samples	Jersey Random Samples	Shorthorn Random Samples	Total
1	6	3	12	22	4	47
2	73	38	229	186	64	590
3	74	55	239	208	100	676
4	78	51	253	195	84	661
5	33	56	163	138	74	464
6	45	22	159	103	66	395
7	25	32	114	96	56	323
8	24	24	83	67	37	235
9	11	19	64	62	26	182
10	8	19	40	34	33	134
11	15	14	41	32	16	118
12	4	11	20	17	8	60
13	1	8	17	18	5	49
14	3	4	9	10	3	29
15	2	1	4	4	4	15
16		2	1	5	1	9
17	1	1	2	1	1	6
18						
19						
20						
Total	403	360	1450	1198	582	3993

The frequency distribution for the dams' ages of the single births is given in Table 4.

Figures 42 and 43 show the distribution on age of the totals of the twin births and the single births on a percentage basis. Figure 42 includes the records for the sires' ages. Figure 43 shows the results for the dams' ages.

From Figure 42 it appears that sires of twin births tend to be younger than the sires of single births. This is particularly noticeable for the frequency of twins from sires under two years of age. Further study will be necessary to determine the significance of this difference.

It will be noted that approximately 49 per cent of the sires of single births are under 4 years of age. That in the same period 56 per cent of the sires that had twin offspring were under 4 years of age.

Another point of much interest arises in any comparison of sires' ages. In one of the papers on the animal husbandry[7] investigations it was shown that 85 per cent of Maine calves are sired by sires under 4 years old. The importance of this fact lies in principle off stated by this laboratory *"the only certain and sure test of the worth of an animal as a breeder is found in the actual performance[8] of that animal's progeny."*

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[7]Pearl, Raymond. 1917. Some commonly neglected factors underlying the stock breeding industry. Annual Report Maine Agricultural Experiment Station for 1917. pp. 1-28.

[8] "In the principle above stated, "performance" is used in the broadest and most inclusive sense. It may mean performance in the show ring, at the butcher's block, in the milk pail, at the shearing shed, in the trap nest, at the race track, in the pulling contest, etc. The essential point is that it is not possible to tell with any certainty by looking at a cow, for example, or its pedigree, whether the heifers from that cow will be good milkers. Nor does the fact that the cow herself is a superior milker ensure or prove that her heifers will be superior milkers. They may be or they may not. The only way to be sure about it is to *try them*. If they are good milkers then the use of that cow as a breeder is by just so much improving the quality of the herd. Again the fact that a bull's dam made a great record at the pail does not ensure that his daughters will be superior milkers. We can only know whether he possesses the ability to transmit dairy productivity by getting the actual records from some of his daughters. If these records are good the breeding worth of the bull is presumptively high. At any rate we know in that case that he is not lowering the average quality of the herd. Nothing else can furnish the sure and certain kind of information which the actual progeny test furnishes."

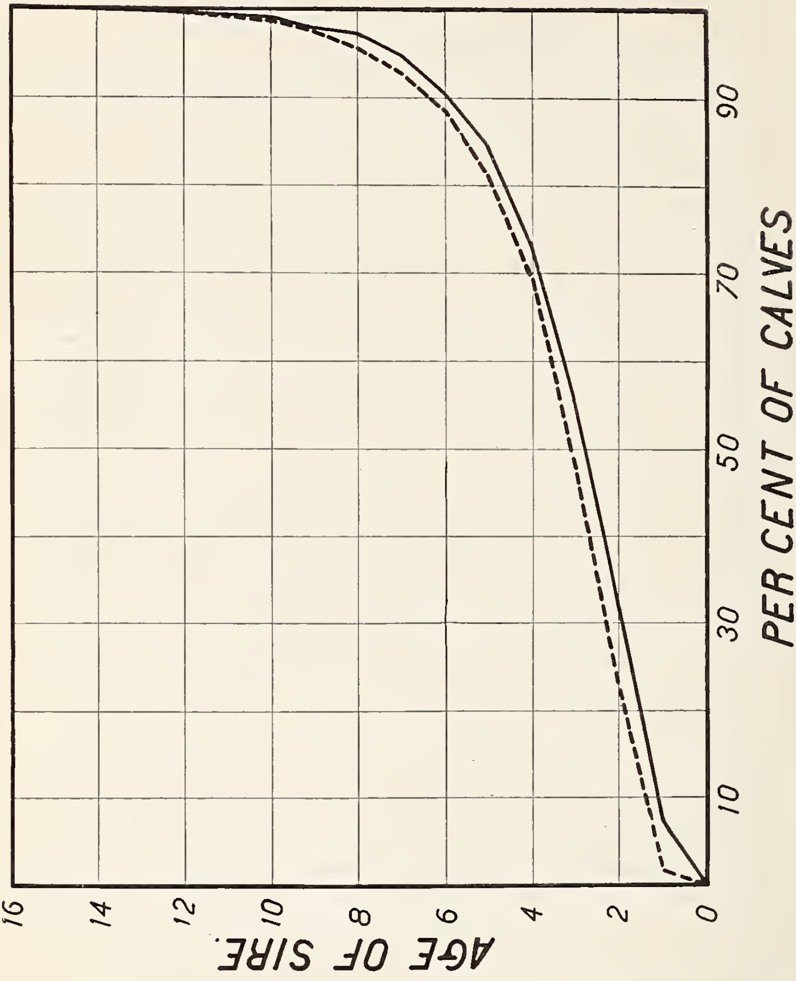

FIG. 42. Relation between age of sire and twinning in cattle. The solid line represents the percentage frequency of twins births for each age of sire. The dotted line represents the percentage frequency of single births for each age of sire.

It takes not less than 3½ years and probably "4 years before the breeder can possibly have had any opportunity to test adequately the milk producing capacity of his daughters. But 85 per cent of all the calves covered in these statistics were sired by bulls under four years and 10 months of age. In other words, in the breeding operations of a large number of Maine's most progressive and wide-awake breeders (for such the cooperators in this record scheme are) more than three-fourths of the calves produced in a given interval of time are sired by bulls about whose ability to transmit milking qualities absolutely nothing definite can by any possibility be known. It is doubtless entirely fair to assume that essentially the same conditions regarding cattle breeding methods obtain in other places generally."

Within the pure breeds one might expect a different condition of affairs. Examination of figure 42 shows that this is in truth partially the case, the average percentage of sires of all calves being about 71 per cent up to 5 years of age. Under these circumstances there are more tested bulls in use among the pure breeds than are in use among the average dairy farmer's herd. Dairymen who handle pure bred stock are consequently more progressive in this regard than the breeders of dairy stock as found on the Maine farm. If there is anything in and of itself in the commonly accepted belief that pure bred stock taken as a whole are better than grade stock, the reason may lie in the fact that a greater proportion of the breeders of pure breds used tested bulls. It may truly be stated in the words used in the previous paper that "it is doubtful if there is any one thing, which every breeder could do if he would, likely to work greater improvement in the average quality of the live stock of the state or nation than the faithful following of the policy of keeping every sire until it was definitely known, by the performance records of the first of his progeny, whether he was adding to or subtracting from the productive value of the herd or flock. Prove the breeding worth of the sire. If it is poor discard him at once and get another. If it is good, keep him as long as possible and by multiplication of his desirable qualities in hs offspring make definite and sure progress."

From the data shown in figure 42 it was shown that the sires under 3 years old produced a slightly greater number of twin births than did those which were older. Figure 43 shows the data on this same point for the dams of these calves. The solid line represents the percentage frequency of the ages of the dams of twin births plotted on age. The dotted line shows the frequency distribution of the dams of single births plotted on age.

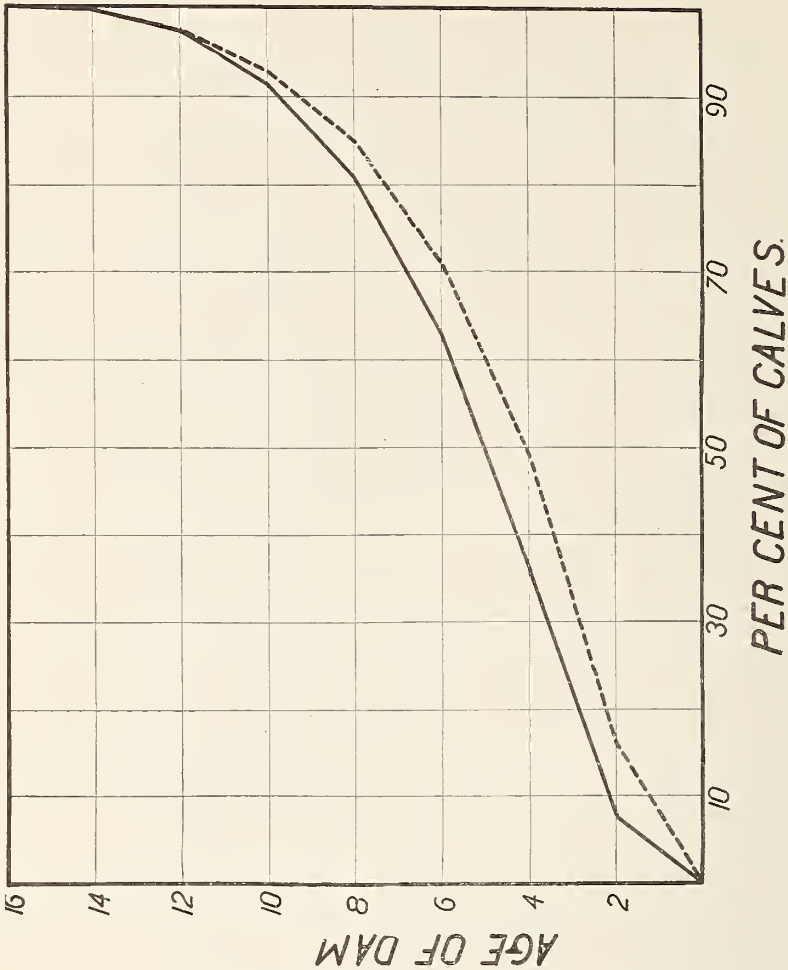

FIG. 43. Relation between Age of Dam and Twinning in Cattle. The solid line represents the percentage frequency of twin births for each age of dam. The dotted line represents the percentage frequency of single births for age of dam.

The frequency distribution of twin births shows that as the cow increases in age the frequency of twin births increases over that of single births. This increase becomes less at the older ages.

Progeny Performances of Holstein-Friesian Sires.

This study had for its object the determination of the transmitting ability of Holstein-Friesian sires for milk yield, butter-fat percentage and butter-fat, the whole to be put in easily understandable, numerical terms. The major objects sought are (1) to determine for each sire the mean or average milk yield of his daughters; (2) to determine for each sire the mean butter-fat percentage of his daughters; (3) to determine the mean butter-fat yield of his daughters; (4) to determine the mean milk yield, butter-fat percentage and butter-fat of all sires as shown by their sons' daughters' performance; (5) pedigree analysis of the sires with daughters which are significantly high in their milk yield and butter-fat percentage in comparison with those whose daughters are significantly low in their milk yield and butter-fat per cent. (6) Pedigree analysis of a random sample of sires without advanced registry daughters.

There are 449 Holstein-Friesian sires which meet these requirements of this test. The average yearly milk yields of the sire's daughters range from 28401.7 to 13006.0 pounds. The sire with the highest average milk yield for his daughters was King Hengerveld Aaggie Fayne. This bull had three daughters with an average age corrected milk yield of 28401.7 pounds. These daughters were 67 per cent in the highest group of milking cows and 33 per cent in the next to the highest group of milking cows. Perhaps the honor for the most significant record belongs to the third sire in the list. This sire, King Segis Pontiac Count, has 10 daughters with an average of 28219.1 pounds of milk. These daughters were all in the highest group of milking cows. The fact which makes this record remarkable is the performance of this large number of daughters and the fact that they were all in the highest class of producers.

If a comparison is made between the average record of the different daughters of a sire and the average record of the race, 48 sires are found which have the progeny performance of their daughters sufficiently high to make it probable that their record is significantly above that of the race. Ten out of 48 sires have enough daughters with a milk yield sufficiently large to make their record more significant than the rest. These sires are King Hengerveld Aaggie Fayne, Piebe Laura Ollie Homestead

King, King Segis Pontiac Count, Colantha Johanna Lad, Pietertje Hengerveld Sir Korndyke, Homestead Girl De Kol Sarcastic Lad, Pontiac Aaggie Korndyke, King Pontiac Champion, King of the Pontiacs and Sir Pietertje Ormsby Mercedes. The sire with the largest number of daughters was King of the Pontiacs with 37 daughters. The average corrected milk yield of these daughters was 22182.7 pounds. The individual records for the total number of daughters were 16 per cent in the highest class, 41 per cent in the next to the highest class, 22 per cent in the third highest group, 8 per cent in the fourth class, 5 per cent in the fifth class, 5 per cent in the sixth class, and 3 per cent in the seventh class or the next to the lowest group of milking cows.

There are 29 sires with a sufficient number of daughters whose average milk yield is low enough to make it significantly below the mean of the advanced registry cows. There are no sires who have sufficient daughters with an average milk yield low enough to be more than significantly below the rest of the breed.

A study of the inbreeding and relationship, as shown in four generation pedigrees, has been made for these two groups of sires (1) second generation 1.04, third generation 3.12, (2) those with daughters of low average milk yield. The data accruing from this study were contrasted for the two groups with the forthcoming results. In the first group (1) there were 4.1 per cent of the total number of sires which showed inbreeding in the second; 20.8 per cent in the third generation and 64.5 per cent in the fourth generation. In the second group (2) there were 0.0 per cent in the second generation, 10.4 per cent in the third generation and 55.2 per cent in the fourth generation which showed inbreeding in their pedigrees. These results indicated that the sires whose daughters are the significantly high producers more frequently show inbreeding in their pedigrees than those sires whose daughters are significantly low producers. The difference is not significant, however.

The study of the pedigrees for the amount of inbreeding showed the following inbreeding coefficients for the first group of sires (1), second generation 1.04, third generation 3.12, fourth generation 8.74 and for the total inbreeding 6.52. The amount of inbreeding for the second group of sires (2) was 0.0

for the second generation, 1.29 for the third, 5.40 for the fourth and 3.04 for the total inbreeding. The amount of inbreeding in the pedigrees of sires whose daughters are high milk producers is shown by these coefficients to be nearly double that of the sires of low producing daughters. The significance of the differences is doubtful.

The amount of relationship between the sire and dam of the first group of sires (1) is 2.08 per cent for the second, 5.21 per cent for the third and 10.41 per cent for the fourth. For the second group of sires these coefficients are 0.0, 1.72 and 4.74. These results indicate a relationship between the sire and dam of the sires whose daughters are high producers, over twice as great as is shown by the sires whose daughters are low producers.

Study of the inbreeding and relationship of a random sample of sires without advanced registry daughters show that they were slightly more inbred than the sires with daughters of significantly high milk yield and considerably more inbred than the sires with daughters of significantly low milk yield. The relationship between the sire and dam of the random sample sires was slightly greater than the relationship between the sire and dam of the sires of high milking cows and twice as great as the sire of low testing cows. These facts show that as ordinarily carried on, inbreeding and relationship are not detrimental to the animal.

Investigation of the pedigrees of these two groups of sires was made in order to determine which animals appear within each group. The findings indicated that, in general, both groups of pedigrees contained the same animals and in about equal proportions. Thus Paul DeKol for the bulls appeared in the pedigrees of the sires with high testing daughters 26 times, DeKol 2d for the cows appeared in this group 28 times. The pedigrees of the sires of low producing daughters showed these animals to appear 12 times in the case of Paul DeKol and 24 times in the case of DeKol 2d. When the number of pedigrees in each group (48 and 29) is taken into consideration it is clear that these animals appear in about equal proportions.

Comparison of the animals appearing in the random sample pedigrees showed that they appear in about equal proportions in the other pedigree groups.

Correlations have been worked out for the animals appearing in these two groups of pedigrees including the division of those which occurred on the sire's and dam's side of the pedigree. These correlation coefficients range from +0.090 to .657. This range for the animals appearing in the random sample pedigrees with those appearing in the pedigree groups of the sires of high and low milking cows is +0.165 to .504. They show that the animals appearing in one group are highly correlated with those appearing in the other groups. Such being the case the question may be asked, how can a breeder determine from a pedigree what sires are going to be those which will have high producing daughters? In the present light of our knowledge the answer appears to be that he cannot.

There are 449 Holstein-Friesian sires who meet the requirements for the butter-fat percentage. The yearly butter-fat percentage for the average of the sires' daughters ranges from 4.503 per cent to 2.820 per cent. The sire with the highest average butter-fat percentage for his daughters was King Hengerveld Aaggie Fayne. All of this sire's daughters were in the highest group of testing cows. The sires with a good number of daughters which were well up in the list of high testing cows, were King Mead of Riverside, Pontiac Aaggie Korndyke and King of the Pontiacs.

Comparison of the sires with the average of the advanced registry cows in conjunction with the probable errors shows that 22 sires have an average butter-fat percentage for their daughters which is sufficient to be significantly high. Six of these 22 sires have a sufficient number of daughters with a high enough butter-fat test to be distinctly significant.

There are 22 sires with a sufficient number of daughters whose average butter-fat test is low enough to make the test significantly below the mean of the advanced registry cows.

A four generation pedigree study of these two groups of sires was made to determine the effect of inbreeding and of relationship within the pedigree, on the butter-fat percentage. The two groups are (1) the sires whose daughters average butter-fat percentage is significantly above the mean of the advanced registry cows; (2) the sires whose daughters' average butter-fat percentage is significantly below the mean of the advanced registry cows.

In the first group 4.5 per cent of the sires showed inbreeding, in the second generation, 18.1 per cent in the third generation, and 68.1 per cent in the fourth generation. The proportionate number of sires which show inbreeding in the group for high butter-fat percentage as compared with that for high milk is consequently approximately the same.

The second group, or the sires with low testing daughters, had 0.0 per cent in the second generation, 18.1 per cent in the third generation, and 63.6 per cent in the fourth generation, of their number inbred. The number within this group which are inbred compare favorably with those in the group (1) of sires with high daughters as given above.

The amount of inbreeding which these two groups of sires exhibit is nearly twice as much for those sires whose daughters are high in their butter-fat test as compared with those whose daughters are low in their butter-fat test. The figures for the different generations are 1.14 per cent for the first group (1) to 0.0 per cent for second group (2) in the second generation; 3.41 (1) to 2.2 for the third generation; 8.82 (1) to 6 95 (2) for the fourth generation. The total inbreeding for the high testing group is 6.19 to 3.86 for the low testing group.

The relationship between the sire and dam of the group of sires of high testing daughters is nearly twice as great as it is for the sires of low testing daughters. The average coefficient for the high testing group is 2.27 for the second; 6.82 per cent for the third and 11.93 per cent for the fourth generation compared with 0.0 per cent for the second, 2.27 per cent for the third and 6.25 for the fourth generation for those sires whose daughters are low in their butter-fat percentage. Here again the significance of these differences is questionable.

Comparison of these results for high and low butter-fat percentage advanced registry sires with those of a random sample of the sires without advanced registry daughters shows that the random sample sires have a greater proportion of their number inbred than the advanced registry sires of high testing daughters or the sires of low butter-fat percentage daughters. If the amount of inbreeding within the group of random sample sires is compared with the amount in the sires of high butter-fat percentage daughters or the sires of low testing daughters it is found that the random sample sire are slightly more inbred. The comparison of the relationship which exists between the sire and dam of the sires within the three groups shows the random sample sire to have slightly more related parents. The differences are not very significant, however.

These facts argue for the belief that inbreeding as normally carried on within the Holstein-Friesian breed has no detrimental effect on milk yield or butter-fat percentage of the daughters of a given sire.

Analysis of the pedigrees of sires whose daughters are high in their butter-fat percentage for the animals contained therein, shows that they contain many of the same animals as the pedigrees of the sires whose daughters are low in their butter-fat percentage. A similar comparison of the animals occurring in the pedigrees of the random sample sires shows that most of these animals also occur in the pedigrees of the two advanced registry groups of sires and in approximately the same proportion.

Each pedigree group and for the divisions, sire's side and dam's side of the pedigree have been analyzed for the appearance of the animals between them. The close similarity between the animals appearing in the pedigrees of high milking group and the low milking group with those of the average pedigree group shows that the appearance of a bull in the pedigree of the high group is no necessary guide to that animal's worth. The fact that a bull whose progeny performance is unknown has a well known bull or bulls in his pedigree is, unfortunately, no indicator of that unknown bull's worth so far as milk production is concerned. Comparison of the animals appearing in the pedigrees of the sires whose daughters' butter-fat percentage is high with those appearing in the pedigrees of the sires whose daughters' butter-fat percentage is low, shows the number appearing in both groups to be less by a slightly significant amount. Such a slightly significant difference indicates to a slight degree that the appearance in the pedigree of an unknown sire of a bull which is known to appear frequently in the pedigrees of sires of high butter-fat percentage daughters is an indication of the worth of the unknown bull as a sire of high butter-fat testing daughters.

The frequency of the appearance of the same animals is significantly greater between groups (high milk yield, low milk yield, high butter-fat percentage and low butter-fat percentage) for those animals on the sire's side of the pedigree than between these groups for those animals appearing on the dam's side of the pedigree. From this, it would seem that more attention is being paid by the breeder to the sire's side of the pedigrees than is being paid to the dam's side of the pedigree.

A greater kinship is indicated between the animals on the sire's side of the pedigrees for the different groups than exists between the animals on the sire's and dam's side of the pedigrees for the same group.

Comparison of the animals appearing in the pedigrees of a random sample of the breed sires with those appearing in the four groups of advanced registry sires shows that the animals in pedigrees of the random sample group are somewhat less frequently found in the pedigrees of the four other advanced registry groups. They are not enough less, however, to preclude the probability that the differences come from random sampling. Such being the case there seems to be no significant difference between the pedigrees of a random sample of Holstein-Friesian bulls without advanced registry daughters and the Holstein-Friesian bulls with advanced registry daughters.

There are 449 sires showing the progeny performance test of Holstein-Friesian sires for butter-fat. The average corrected butter-fat production ranges from 1278.93 pounds to 421.39 pounds. This range is increased nearly 270 pounds by the sire, King Hengerveld Aaggie Fayne, a bull with daughters of very high milk yield and butter-fat percentage. It is doubtful, however, if this bull is as good as the record of these three daughters make him appear for he had another daughter with a record of less than a year which was relatively low. Such being the case, it would appear that the high range should be reduced somewhat.

There are 37 sires whose daughters' butter-fat production is sufficiently high to make it significantly above that of the race. The sires, King Hengerveld Aaggie Fayne, Friend Hengerveld DeKol Butter Boy, King Segis Pontiac Count, Pontiac Aaggie Korndyke and King of the Pontiacs have enough daughters with a sufficiently large average butter-fat yield to make their production quite significantly high.

There are 19 sires who have enough daughters with an average butter-fat yield to make their record significantly low.

There are 263 sires who have one or more sons with year test daughters. These sons are gathered together under their sires. The average milk yield, butter-fat percentage and butter-fat is determined for each son's daughters, for the sire's daughters and for the average of the sire's sons. The sire, King Fayne Segis with three sons has the highest average butter-fat percentage for his sons. The average is 1029.85 pounds of butter-fat for the age corrected yield.

INHERITANCE OF MILK YIELD AND BUTTER-FAT PERCENTAGE AS INDICATED BY FIRST GENERATION CROSSES.

This paper gives briefly the facts discovered on the inheritance of milk yield by the use of the crossbred herd.

It is found that Crossbred No. 1 resembles her low producing parent 7.7 times as closely as she does the high producing parent. The other eleven crossbreds resemble the high producing line of milk production from 1.5 to 18.0 times as closely as they do the low line of milk production. If this paralleling of the high line production is averaged it is found that they resemble the high line of production 4.76 times as closely as they do the low line. These facts argue for the transmission of milk production by factors which show partial dominance. It would not seem that they argued for increased vigor of heterosis only,—because of the case of Crossbred No. 1 where the low line milk yield was definitely transmitted instead of the high yield. In fact it would appear that this Crossbred is more likely to be a segregate of low milking factors from the high milking factors carried by her dam.

Three levels of milk production are crossed in these experiments. The Aberdeen Angus cattle constitute the lowest level, the Jersey, Guernsey and Ayrshire cattle averaging about the same in milk yield constitute the intermediate level of production and the Holstein-Friesian cattle having the highest yield represent the highest level of production. It is of some interest to compare the results of crossing the different levels. If we omit the result of Crossbred No. 1 it is found that the Holstein-

Friesian cows or bulls mated to the second group of cows or bulls (Jersey, Guernsey or Ayrshire) produced offspring who are 8.43 times as near the milk production of the high level on the average as they were the low line of production.

The only cross involving the Holstein-Friesian and Aberdeen Angus, Crossbred No. 44, was 2.2 times as close to the high line of production as she was close to the low line of her parents' milk yield.

It is of interest to note in this connection that Crossbred No. 44's milk yield resembles closely the milk yield of the intermediate group (Jersey, Guernsey and Ayrshire) of these experiments.

The crosses involving the second level of milk production (Jersey, Guernsey and Ayrshire) mated to the third group Aberdeen Angus, had crossbred offspring resembling the high line 7.7 times as closely as they did the low line of production. This figure compares favorably with that of the Holstein-Friesian x Jersey crosses.

If the crosses are compared to determine what effect the high line on the sire's side of the cross may have in comparison with the effect produced by the high line being on the dam's side of the cross it is found that the results in the three lines are contradictory. When the Holstein-Friesian sires were mated to second class dams, Guerneys, the offspring resembled the high line 11.3 times as closely as she did the low line. When the Jersey sire, second class, was mated to the Holstein-Friesian cows, highest class the milk production once resembled the high class 2.7 to 1 and once the low line 7.7 to 1. The crosses involving the highest milk line, Holstein-Friesian bull, to the lowest milking line Aberdeen Angus cow produced an offspring resembling the high line 2.2 times as closely as the low line. The crosses of the second level in milk production to the third level show that when the higher level is on the sire's side the daughters resembled the high line 3.6 times as closely as they do the low line. When this higher level is on the dam's side the daughters resembled the high line 9.34 times as closely as they did the low line. It seems doubtful from these results if there are modifying sex linked factors present.

These observations may be regrouped to show the changes brought about in the butter-fat percentage of the offspring in accordance with the way the cross was made. For those crosses in which Holstein-Friesian sire was used the offspring in all cases resembled the low testing sire between 3.3 and 4.5 to 1 as closely as they did the high testing parent, the mean being 3.9 to 1. For those crosses in which the dam was of the Holstein-Friesian breed the results of the offspring were contradictory one approaching the butter-fat percentage of the high test parent 1.4 to 1 and the other approaching the butter-fat test of the low Holstein-Friesian cow 7.3 to 1. The cross involving the Ayrshire dam resembled the low test 2.6 to 1. The high test Guernsey dam when crossed to the lower test Aberdeen Angus sire had a daughter which resembled the low testing sire 5.5 times as closely as she did the high testing dam.

Considering every cross irrespective of their merit for this particular phase of the work the crosses resemble the low testing parental breed 2.23 times as closely as they do the high testing parental breed.

It is of interest to examine the results of these experiments on butter-fat percentage in the light of those for milk yield. It will be remembered that in the F_1 crossbreds milk yield was intermediate between that of the high and the low parents but approached most nearly that of the high parent. In the genetics of many economic characters as yield of grain, size of the animal etc. the explanation used to account for such a phenomena is the heterozygous nature of the factors contained in the F_1 animal as compared with the homozygous nature of the factors in the parental breeds or strains. Without question there may be something to this hypothesis for certain crosses. .The results for milk yield and butter-fat percentage do present a paradoxical position when this hypothesis is applied to them. Thus milk yield is increased over what the true intermediate should be. This follows the expectation generally agreed upon and accounted for by heterosis. But on these identically same animals the butter-fat percentage is decreased below the intermediate. This is not the expectation generally considered as due to heterosis although it is by no means impossible to assume that increased vigor may reduce rather than increase a character. The double nature of such a position does not appeal to the author, however, as furnishing more than a verbal explanation of the results. The explanation which really seems most likely is that we have in these two cases the resultant of partially dominant factors. Numerous similar cases can be cited in genetics literature. Perhaps the best known case is that of black in Drosophila where the factor for this is normally classified as a recessive but where if occasion demands it may be used as a dominant; such a factor differs quite distinctly from another like speck which is consistently recessive. Such a parallel will explain the inheritance for butter-fat percentage by considering that the factors for low butter-fat percentage display more dominance in their expression than do the factors for high butter-fat percentage.

The inheritance of butter-fat percentage has occupied a prominent place in the discussions of breeding operations by practical dairymen. These men have held the following views as to the mode of this inheritance. The first has claimed that the tendency for high or low butter-fat percentage is transmitted by the sire to his offspring; the second that the dam transmits the tendency for high or low butter-fat percentage to the offspring; and the third that both parents contribute to the butter-fat percentage transmission. The results of these experiments show that the third of these claims is correct. Such being the case the dairyman who wishes his breeding operations to progress successfully will find it desirable to examine both sides of his animals' pedigrees carefully. Thus, today, the Jersey breeder pays a good deal more attention to the sires' side of the pedigree than he does the dams' side of the pedigree when in truth both sides are equally important.

Mendelian Experiment on the Inheritance of Milk Yield and Butter-Fat Percentage.

As the results herein described show the crossbred herd is beginning to furnish data of value in the study of the inheritance of milk yield and butter-fat percentage. It will be remembered that in the second generation lies the separation and recombination of the inheritable units which cause inheritance. It is in this generation therefore that the complete results of this work are expected. The second generation crosses are rapidly being made available for study.

Table 5 gives the mating and the animals born during the past year.

TABLE 5.

Calves which have been produced in the hybridization experiments between October, 1919 and October, 1920.

Calf No.	Sex	Dropped	Sire's Name and Registry Number	Breed of Sire	Dam's Name and Registry Number	Breed of Dam
91	♂	Nov. 9, 1919	Crossbred No. 32	Aberdeen Angus x Guernsey	Crossbred No. 26	Aberdeen Angus x Guernsey
92	♂	Dec. 6, 1919	Crossbred No. 9	Aberdeen Angus x Holstein-Friesian	Orono Madge (192781)	Aberdeen Angus
93	♀	Dec. 28, 1919	Crossbred No. 17	Aberdeen Angus x Jersey	Crossbred No. 15	Jersey x Aberdeen Angus
94	♂	Dec. 31, 1919	Kayan (167617)	Aberdeen Angus	Crossbred No. 52	Holstein-Friesian x Aberdeen Angus
95	♂	Jan. 9, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 34	Jersey-Holstein-Friesian x Jersey
96	♀	Jan. 10, 1920	Crossbred No. 9	Aberdeen Angus x Holstein-Friesian	Eventime 4th (155526	Aberdeen Angus
97	♀	Jan. 11, 1920	Nepaul (23330)	Guernsey	Crossbred No. 22	Aberdeen Angus x Guernsey
98	♀	Feb. 25, 1920	Envious Majestic (17526)	Ayrshire	Crossbred No. 37	Aberdeen Angus x Ayrshire
99	♂	Mar. 18, 1920	Crossbred No. 32	Aberdeen Angus x Guernsey	Crossbred No. 29	Aberdeen Angus x Guernsey
100	♀	Apr. 2, 1920	Crossbred No. 9	Aberdeen Angus x Holstein-Friesian	Hearthbloom (147141)	Aberdeen Angus
101 } 102 }	twins ♂	Apr. 11, 1920	Crossbred No. 35	Holstein-Friesian x Jersey	Crossbred No. 1	Jersey x Holstein-Friesian
103	♀	May 27, 1920	Crossbred No. 9	Aberdeen Angus x Holstein-Friesian	Orono Ellen (192783)	Aberdeen Angus
104	♀	June 8, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 25	Jersey-Holstein-Friesian x Jersey-Holstein-Friesian
105	♂	June 18, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 42	Jersey-Holstein-Friesian x Jersey
106	♂	June 29, 1920	Crossbred No. 31	Jersey x Aberdeen Angus	Crossbred No. 27	Jersey x Aberdeen Angus
107	♂	July 1, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 11	Jersey x Holstein-Friesian
108	♂	July 29, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 55	Aberdeen Angus-Jersey x Jersey Aberdeen Angus
109	♂	Aug. 1, 1920	College Segis Shepard (220133)	Holstein-Friesian	Crossbred No. 57	Holstein-Friesian x Aberdeen Angus
110	♂	Aug. 10, 1920	Kayan (167617)	Aberdeen Angus	Crossbred No. 47	Holstein-Friesian x Aberdeen Angus
111	♀	Aug. 12, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 16	Aberdeen Angus x Jersey
112	♂	Aug. 17, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 46	Holstein-Friesian x Jersey
113	♂	Aug. 26, 1920	Kayan (167617)	Aberdeen Angus	Crossbred No. 45	Aberdeen Angus x Holstein-Friesian
114	♀	Sept. 7, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 61	Jersey x Holstein-Friesian
115	♂	Sept. 19, 1920	College Segis Shepard (220133)	Holstein-Friesian	Crossbred No. 62	Aberdeen Angus x Holstein-Friesian
116	♀	Sept. 28, 1920	Nepaul (23339)	Guernsey	Crossbred No. 12	Holstein-Friesian x Guernsey
117	♀	Oct. 10, 1920	Kayan (167617)	Aberdeen Angus	Crossbred No. 44	Holstein-Friesian x Aberdeen Angus
118	♀	Oct. 11, 1920	Crossbred No. 9	Aberdeen Angus x Holstein-Friesian	Orono Hearthbloom 2d	Aberdeen Angus
119	♀	Oct. 18, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 59	Holstein-Friesian-Jersey x Jersey-Holstein-Friesian
120	♀	Oct. 19, 1920	Lakeland's Poet (102603)	Jersey	Crossbred No. 64	Holstein-Friesian x Jersey

THE EFFECT OF MODIFYING MILK FOR BUTTER-FAT CONTENT ON THE CONTENT OF THE OTHER SOLIDS

During the year a number of enquiries have been received by the author as to the effect on the percentage of the other solids of modifying whole milk to a definite standard of butter-fat percentage. Concretely stated, will a milk containing 5.00 per cent of butter-fat when modified by the extraction of butter-fat to a constant standard, say 3.80 per cent butter-fat contain as much in food value, less in food value or more in food value than a whole milk of 3.80 per cent fat? Similarly what will a milk having a butter-fat per cent of 2.00 contain in nutriment when modified to a butter-fat percentage of 3.80 per cent? These questions refer to the content of solids-not-fat. Table 6 gives a summary of the facts for the different breeds as compiled from numerous sources.

TABLE 6.

Butter-Fat Percentage and Solids-not-fat Percentage for Whole Milk of some of our Leading Breeds.

Breed	Total Solids %	Butter-Fat %	Solids-not-fat %	Difference solids-not-fat % from 8.60
Jersey	14.39	5.12	9.27	.67
Polled Jersey	13.93	4.67	9.26	.66
Guernsey .	13.61	4.53*	9.08	.48
French Canadian	13.32	4.00	9.32	.72
Shorthorn	12.61	3.70	8.91	.31
Red Polled	12.66	3.67	8.99	.39
Brown Swiss	12.61	3.62	8.99	.39
Ayrshire	12.46	3.62	8.84	.24
Holstein-Friesian	12.02	3.44	8.60	.00
Dutch Belted	12.31	3.40	8.91	.31

*The determination of the butter-fat percentage for the Guernsey advanced registry cattle came out 5.02 per cent for the 5600 cattle used. Such being the case it appears probable that the figure 4.53 from the official analysis is on rather poor cows of the breed.

The first column of table 6 gives the breed of the cow. The next column gives the total solids per cent as compiled from several analyses. The third column gives the butter-fat percentage. The fourth column gives the solids-not-fat percentage. It will be noted that the Holstein-Friesian breed has the lowest solids-not-fat percentage. The fifth column shows the difference of the solids-not-fat percentage for the breed from the 8.60 of the Holstein-Friesian or lowest average per cent.

Study of this table shows that if the milks of the cows whose butter-fat percentage were over 3.80 were modified by the extraction of butter-fat to a percentage of 3.80 that the purchaser would receive a higher percentage of solids-not-fat in his milk than if the milk were of 3.80 per cent to start with. To illustrate if the purchaser bought average modified Jersey milk he would receive .36 per cent more solids-not-fat than if he bought natural Shorthorn milk whose average butter-fat percentage is nearly the 3.80 per cent of the modified milk. If, however, a milk of relatively low butter-fat percentage were modified by the addition of butter-fat to 3.80 per cent the purchaser would receive less solids-not-fat than he would receive from a natural milk of 3.80 per cent.

Similar facts hold for the animals within the Holstein-Friesian breed. The Holstein-Friesian Association has published records of the solids-not-fat for 335 of their cattle on advanced registry tests. These 335 records show that for this breed within a range of butter-fat percentage of from 2-4 to 4-8 the total solids stand in the relation indicated below.

$$\text{Total solids } \% = 6.992 + 1.465 \text{ Butter-Fat } \%$$

That is, if we have a Holstein-Friesian milk of 2.5 per cent butter-fat we would expect the total solids per cent to be 1.465 x 2.5 to which is added 6.992 to give a total of 10.655. Below are tabled the results of the solution of this equation for the butter-fat percentages of 2.5, 3.5, 4.5. You will note that the total solids go up as the butter-fat percentage increases. The rate of increase for the solids-not-fat is not, however, in direct proportion to the rate of increase of the butter-fat percentage.

Butter-Fat %	Total Solds % .	Solids-Not-Fat %
2.5	10.655	8.155
3.5	12.120	8.620
4.5	13.585	9.085

The average error expected in calculating the total solids per cent from the butter-fat percentage of individual cows for the 365 day test on this basis is .172 per cent and the maximum error expected is .516 per cent.